Formula of the Invention

1. A method for the analysis of impurities in a main gas which involves an ionization of impurity atoms and molecules in their collisions with particles of definite energy in an ionization chamber; a measurement of electric current between, at least, two electrodes positioned in said chamber, as a function of the voltage applied between two said electrodes, differing in that said main gas pressure and said ionization chamber geometry are chosen in such a way that a distance between any point in said chamber and the nearest chamber wall or one of said electrodes is less than a mean displacement of an electron before it loses a given portion of its kinetic energy; equipotential space is provided at the region of said ionization chamber, where said ionizing collisions occur, said current dependence on the voltage applied to said inter-electrode gap is used to find the amount of electrons with characteristic energies, which are generated in the ionization of said atoms or molecules, said impurities in said main gas are identified by the parameters of said electrons.
2. The method according to claim 1 differing in that a noble gas is used as said main gas.
3. The method according to claim 2 differing in that said main gas is helium.
4. The method according to claims 1-3 differing in that said main gas pressure may vary from 10 to 10^5 Pa and above.
5. The method according to claims 1-4 differing in that a voltage applied between two said electrodes is varied from 0 to the ionization threshold of said main gas, and the amount of said electrons with the characteristic energies is determined from the second derivative of the electric current dependence on the voltage applied.
6. The method according to claims 1-5 differing in that said equipotential space is created in said ionization chamber region by using a pulsed power source to produce an afterglow plasma in the ionization chamber; said impurity atoms or molecules are ionized in collisions with metastable atoms or molecules of said main gas, generated under the effect of said pulsed power source; said current is measured with a time delay following the power source pulse effect; the concentration and temperature of the charged particles in the afterglow plasma at the moment of measurement are provided so that the Debye length is much less than the dimensions of said ionization chamber.
7. The method according to claim 6 differing in that a pulsed glow discharge ignited between said electrodes is used as a said pulsed power source.
8. The method according to claim 6 differing in that a pulsed laser radiation as a said pulsed power source is used to create plasma in the gap between said electrodes.

9. The method according to claims 6-8 differing in that said impurity atoms or molecules are ionized when said afterglow plasma is irradiated by photons of a given energy from an external source.

10. The method according to claim 9 differing in that said impurity atoms or molecules are ionized by irradiation by photons resonant to the atoms or molecules of said main gas.

11. The method according to claims 1-10 differing in that said electrodes of a plane shape and parallel each other are used, simultaneously performing the role of the walls of said ionization chamber.

12. The method according to claims 1-11 differing in that said ionization chamber is used with *N* insulated cathodes positioned inside; an individual voltage with respect to one or several anodes is applied to each cathode; the current across each of the *N* cathodes is measured; the amount of electrons with the characteristic energy values, which are generated in the ionization of the impurity atoms or molecules, is found from combined data on the currents measured.

13. The method according to claims 1-5 differing in that a conducting grid is placed between said electrodes, which is electrically connected to the anode to create an equipotential space between them; the impurity atoms or molecules are ionized by irradiating the space between said grid and said anode by neutral particles of definite energy from an external source.

14. The method according to claim13 differing in that said electrodes and said grid have a plane shape and are arranged parallel to one another; said electrodes also perform the function of the ionization chamber walls.

15. The method according to claims 13-14 differing in that the impurity atoms or molecules are ionized by photons resonant to the atoms of said main gas.

16. The method according to claims 13-15 differing in that electric charge passed across cathode is controlled; when said charge exceeds the prescribed value, said external source is turned off and an electric field is applied until the charged particles are removed from said inter-electrode gap; then said external source is turned on and the current is measured again.

17. The method according to claims 13-16 differing in that *N* insulated cathodes are positioned in said ionization chamber; an individual voltage relative to corresponding grids and one or several anodes is applied to each cathode; the individual current across each of the *N* cathodes is measured; combined measured current values are used to find the amount of electrons with the characteristic energies, produced in the ionization of said impurity atoms or molecules.

18. The method according to claims 1-17 differing in that the impurities to be analyzed are provided by a target sample material atomization with an additional power source; the impurities formed are mixed with said main gas and are delivered into said ionization chamber.

19. The method according to claim 18 differing in that said target sample is used as a cathode atomized by a preliminary plasma discharge ignited by said additional power source.

20. The method according to claims 1-19 differing in that the impurity molecules are pre-dissociated into atoms in an additional plasma discharge and the atomic composition of said impurities is analyzed.

21. An ionization detector for the analysis of the impurities composition in a main gas, comprising an ionization chamber filled with said gas mixture and, at least, two electrodes inside of said chamber; a power source generating particles with definite energy to ionize said impurity atoms or molecules; a measuring circuit to detect electric current as a function of the voltage applied to said electrodes, differing in that said main gas pressure and the ionization chamber geometry are chosen in such a way that a distance from any point inside of said ionization chamber to nearest chamber wall or one of said electrodes is less than a mean displacement of electrons before they lose the chosen portion of their kinetic energy; an equipotential space provided at the region of said ionization chamber where said impurities ionization occurs; said measuring system is capable to determine the amount of electrons with characteristic energies, produced during the ionization of said impurities

22. The ionization detector according to claim 21 differing in that a noble gas is used as said main gas.

23. The ionization detector according to claim 22 differing in that helium is used as said main gas.

24. The ionization detector according to claims 21-23, differing in that said main gas pressure varies from 10 to 10^5 Pa and more.

25. The ionization detector according to claims 21-24 differing in that the voltage applied between two said electrodes is varied in the range from 0 to the ionization threshold of said main gas, and said measuring system is designed capable to find second derivative of the current dependence on the voltage applied to determine the amount of electrons with the characteristic energy values.

26. The ionization detector according to claims 21-25 differing in that said power source is a pulsed generator to create an afterglow plasma in said ionization chamber; the measuring system is designed capable to register the electric current with a time delay after the plasma

generator pulse; said generator is capable to produce sufficient concentration of metastable atoms of the main gas to register the electrons with the characteristic energies, formed in the impurities ionization by said metastable atoms, said generator also capable to produce such concentration and temperature of charged particles in the afterglow plasma that the Debye length is much less than the dimensions of the ionization chamber at the moment of the current measurement.

27. The ionization detector according to claim 26 differing in that said power source ignites a pulsed glow discharge between two said electrodes.

28. The ionization detector according to claim 26 differing in that said power source is a pulsed laser creating plasma between two said electrodes.

29. The ionization detector according to claims 26-28 differing in that an additional external source of photons of definite energy is installed to ionize the impurity atoms or molecules in the afterglow plasma.

30. The ionization detector according to claim 29 differing in that said additional external source is installed to generate photons resonant with the atoms or molecules of said main gas.

31. The ionization detector according to claims 21-30 differing in that said electrodes of plane shape, parallel each other are used, simultaneously performing the role of walls of said ionization chamber.

32. The ionization detector according to claims 21-31 differing in that said ionization chamber comprises N insulated electrodes; an individual voltage is applied to each said electrode relative to one or several connected anodes; said measuring system is capable to measure the individual electric current across each of N said cathodes as a function of the applied voltage.

33. The ionization chamber according to claims 21-25 differing in that a conducting grid is positioned between two said electrodes and is electrically connected with said anode to create an equipotential space between them; an external source of neutral particles of a definite energy is installed in such a way that the impurity atoms or molecules are ionized due to the irradiation of the space between said grid and said anode.

34. The ionization detector according to claim 33 differing in that said electrodes and said grid of plane shape and parallel each other are used; said electrodes additionally perform the role of the walls of said ionization chamber.

35. The ionization detector according to claims 33-34 differing in that said external source generates photons resonant with the atoms or molecules of said main gas.

36. The ionization detector according to claims 33-35 differing in that said measuring system is designed capable to control the current across said cathode; when this current exceeds a prescribed value, said measuring system turns off said external source, applies an electric field until the charged particles are removed from said inter-electrode gap, then turns on said external source again and continues to measure the current.

37. The ionization detector according to claims 33-36 differing in that said ionization chamber contains *N* insulated cathodes; individual voltage is applied to each said cathode relative to corresponding grid and one or several anodes; said measuring system is designed capable to measure the current across each of said *N* cathodes individually.

38. The ionization detector according to claims 21-37 differing in that an additional power source is used to atomize a sample target material as an impurity into said main gas and supplying said impurity mixed with said main gas to said ionization chamber for the composition analysis.

39. The ionization detector according to claim 38 differing in that said sample target is installed as a cathode for atomization by a preliminary plasma glow discharge ignited by said additional power source.

40. The ionization detector according to claims 21-39 differing in that an additional plasma discharge source is used to provide pre-dissociation of sample molecules into atoms for the analysis of the elemental composition of the sample in said ionization chamber.

41. The ionization detector according to claims 33-37 differing in that said external radiation source is filled with argon and comprises a cylindrical window transparent to this radiation; two electrodes on the butt sides of said window, a power source to ignite a gas glow discharge; said anode, said cathode and said grid for photoelectron detection are plane-parallel rings arranged coaxially outside of said cylindrical window of the radiation source in such a way that the radiation penetrates only the space between said anode and said grid.